The Synapse

Oberlin College Science Magazine

GMOs

Curiosity

Mushroom Cults

Life at the End of the Hall

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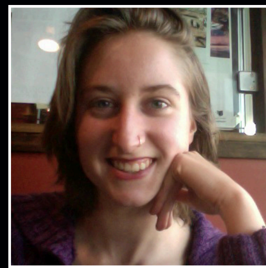
Oberlin College Science Magazine

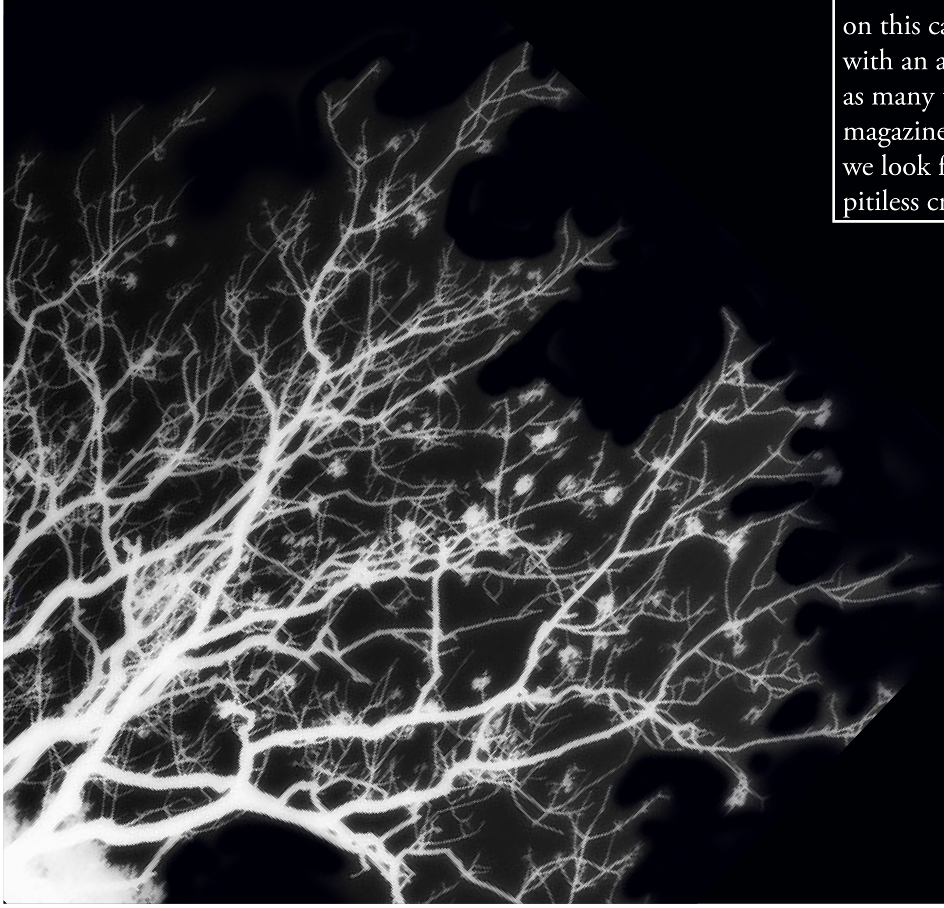
The Synapse is a relay point of science-related information with a twofold objective. First, we aim to stimulate campus interest in science by exposing students to its global relevance and contributions. Second, we strive to facilitate collaboration between members of the Oberlin College community, especially within the natural science departments.

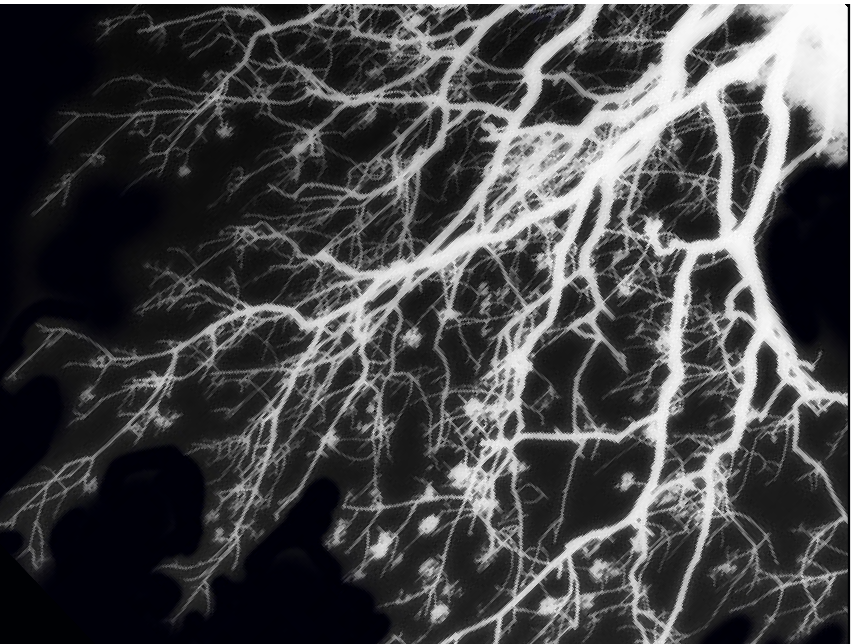
Oberlin College
Oberlin, Ohio
April 2015



My interest in science began comparatively late in my Oberlin life, as a wayward conservatory student who impulsively enrolled in a neuroscience course. I found myself intrigued by vast pools of knowledge of which I had only the most superficial understanding. It struck me that scientists lived in a marvelously fast-paced world with fresh discoveries around every corner. However, this thrill of novelty is entirely lost on the lay public, who rarely make it past the dense technical language of scientific publications. In my work for the Synapse, I hope to fill this accessibility gap, and bring the latest ideas of research to the broader college campus, where they can be criticized from sociopolitical and moral points of view.

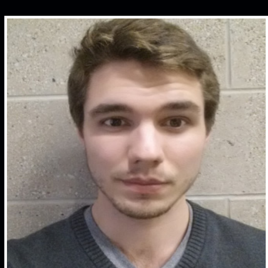
Organizationally speaking, the sheer number of students that came to our general interest meeting despite its inconvenient timing before final exams indicated to me that passion for science journalism on this campus runs deep. We rebuilt the Synapse with an almost entirely new team, aiming to involve as many underclassmen as possible to create a robust magazine for future generations of Obies. As always, we look forward to reading your future submissions, pitiless critiques and wildest journalistic dreams.





Everyone, What's up --

I still remember issue 0 of The Synapse, for which I wrote a column called *What's Up Weelic.* Maybe it's something about the way I wrote (because I wrote as I talked), but the founding editors, Veronica Burnham and Francis Lawrence, asked me to become an editor. But I thought that as a second-year, maybe my writing wasn't that great, and so I didn't step up to do something for the magazine that I now love writing for. I regretted that; The Synapse went dormant. Fast forward two years, and Emily prodded me (and others), and I did some prodding too, and now we have issue #4, a mix of new and unpublished articles. I'm glad it's back, but I also wish to see it continue after I go. If you liked reading The Synapse back then, you are probably graduating now. (I'll see you at Commencement!) If you like The Synapse as we are right now, I encourage you to step up and bring your skills and make a magazine happen. If you don't like it, don't just tell us what's wrong, be part of us and make it better. (email Hillary Pan, our liaison at hpan@oberlin.edu or synapse@oberlin.edu) The potential for change is here and now. Pass it on. I hope you will pass it to friend or stranger to read after you are done (there's only 500 copies), but more than that, I hope you would take on the creation of this Obie magazine.



Two years ago I arrived on Oberlin's campus for the first time in my life. I arrived, as is the case for many of our readers, as a high school student in search of a place that I would call home for the next four years of my life. It was a quick and dirty encounter with Oberlin's campus. I toured the dorms, I toured Mudd, I had ice cream at Gibsons and, after an eternity of walking, I toured the Science Center. It was there, sprawled out on a couch in Love Lounge, that I read my first Synapse. It was the original magazine, Issue 0, a version unlikely to be found today, chock full of young scientists' take on the natural world. It was sleek, intelligent, and humble. I loved it. It showed me a world beyond the grind of academia. A plane occupied solely by the words of dedicated Obies united in a common vision: to channel their passion for science into a single entity. It was no coincidence that they called their magazine *The Synapse*, as it functioned as the relay point between a scientific community and the greater Oberlin community. They worked tirelessly to give you three brilliant issues. Now, after two years of labor and a semester hiatus, I am proud to say that The Synapse is back. I implore you to lose yourselves in it's pages. To delve into the exciting articles our diverse staff of authors, artists, and editors has prepared for you. Let your imagination and scepticism loose. And, in keeping with sciences' self-correcting mechanisms; send us your comments, criticisms, doubts, questions, and epiphanies. Enjoy.

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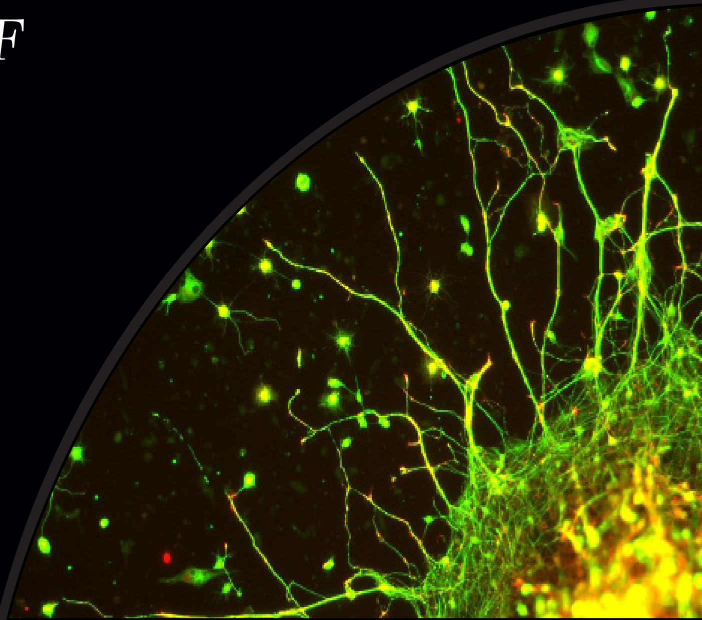


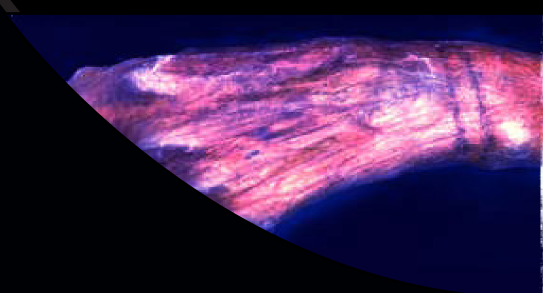

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The Door at the End of the Hall

Or

Why There is Life on Earth, and Why We Should Have Seen It Coming

Kirk Pearson

My mom occasionally recounts a memory of four-year-old me running through the halls of our local natural history museum, thoroughly pissing off security guards, couples, and school groups. I recall spending more time running through the museum than actually learning from it, although one particular exhibit still somewhat haunts me. This was the museum's interactive timeline, where a visitor could walk down our evolutionary tree in retrograde— beginning with Homo sapiens and devolving past mammals, dinosaurs, tetrapods, early chordates, and winding up next to the woefully uninteresting archaebacteria panel. But the section I remember best wasn't technically part of the exhibit. It was an empty storage room that sat all the way at the end of the hall. It was (allegedly) a model of primordial Earth that was damaged in the late '80s and never reconstructed. As far as I was concerned, my evolutionary tree ended with Homo sapiens, and began with a storage facility.

To this day, I've never forgotten that room.

This abrupt (and rather anticlimactic) ending to the timeline of life has been a subject of heated debate since before the foundation of modern science. Even to modern paleontologists, life without a beginning seems a bit like life without an explanation. The scientific community has been perpetually stuck in that storage room since the early 19th century.

One of the first major glimpses into that room was in 1953, in a small UChicago chemistry lab. Stanley Miller, a biology PhD candidate, filled a glass vessel with a combination of methane, ammonia and hydrogen gas in an attempt to simulate Earth's atmosphere. His setup came complete with an electrical discharge (to simulate lightning) and a separate container to supply water vapor. After several months of letting his chemical mix broil, he found over twenty amino acids floating in his primordial soup. The lab took this to mean that you could make life in the same way you make pancakes. Just take an innocuous mix, add some frills, and push the re- action in the right direction.

Of course, nobody's making pancakes with only those instructions to go by. Since the '50s, the majority of biogenesis studies were pretty much just as vague: you'll need the right amount of stuff in just the right conditions and if you're really, really lucky, you might stumble upon an amino acid. At least, this was the notion until last year, when physicist Jeremy England published a provocative new idea that claimed just the opposite.

What if luck wasn't all that necessary in making life?

England, a physicist at MIT, argues that life on Earth isn't that special at all. In fact, life might have been entirely inevitable. Biogenesis could be, in England's words, "as unsurprising as rocks rolling downhill."

This new theory calls for a "dissipation-driven adaptation of matter," and if it's correct, could be one of the most important biology studies of the past twenty years. In the eye of a physicist, living things are especially good at two things: absorbing energy from their environment, and radiating it off in the form of heat. If enough energy is applied to a clump of carbon atoms, they will slowly restructure themselves just so they can dissipate more energy— it's a chemical guarantee. The mysterious force at work? It's the second law of thermodynamics: the idea that a closed system will give off energy, but never take any of it back. You can scramble an egg, but you can't unscramble it. You can melt an ice cube, but you can't make it turn back into ice without putting it in the freezer (or with the help of late 90s Arnold Schwarzenegger). Simply put, all things move from a state of order to disorder. And as things get more and more disordered, they scatter more of their energy out into the universe.

Molecules, much like scrambled eggs, will automatically spread their energy out over time. They will continue to make newer and more efficient shapes until they reach what's called a thermodynamic equilibrium, a point of total disorder. In the case of an ice cube, it will continue to melt until it turns to a gas: its disordered state will spread across its container, fogging up the glass in the process. England claims that the basic molecules of life exist in that equilibrium state — all life needed was time to form its molecules into the shape that would allow for maximum dissipation. Just as your eggs can't unscramble themselves, your molecules won't ever be able to regress back to an ordered state. It's a process that, like boy bands or rolling down a hill, only works in one direction.

Writes England, "You start with a random clump of atoms, and if you shine light on it for long enough, it shouldn't be so surprising that you get a plant."

This paper isn't without its detractors, however, and no conclusive tests of this theory have been made on actual living systems. But, looking beyond its scientific reception, England's work adds to the many creative interpretations of biology's fundamental question. His relatively simplistic take on the problem is a testament to our endless fascination with biogenesis, as well as life's end, and overarching philosophical purpose.

One especially quirky field has taken to the paper with zeal: astrobiology. If the prerequisites for life are really as lax as England claims, the search for extraterrestrial life becomes quite a bit different. On February 17th, NASA announced the discovery of the 29th known habitable exoplanet (and counting!). Next time you look at the night sky, take some time to remember that life might be inevitably evolving across your entire field of vision. It's just a matter of time.

Next time you look at the night sky, take some time to remember that life might be inevitably evolving across your entire field of vision.

England's paper kept pestering me for a while, and it started to make me feel there was a reason I so vividly remembered the museum's storage room. I never get sick of thinking about that room because there's something about it that summarizes everything mysterious about what the exhibit represents. On one hand, you know it's just an empty room, but it never stops being an odd and quirky finale to such a dramatic timeline. In another way, it's an unintentionally perfect beginning to the story of life. A silent room— completely blasé and motionless, but radiating with biological potential. Despite our academic inclination to oversimplify vast, philosophical questions, the exhibit's unintentional finale might have been the best possible way to represent the origins of life.

Regardless of the future of England's theory, I'll always envision the emergence of life as that room, both alien and comforting at once. That storage room sits at the start of our evolutionary tree, always simmering with the energy to help guide us forward.

The Future of Science Education in Elementary School

by Anah Soble

Somewhere between the 1st and the 6th grade we all learn that opposite poles attract, that the mitochondria is the powerhouse of the cell, and that the three basic types of rocks are igneous, metamorphic, and sedimentary. Throughout our early education, many of us would cheer when we found out we would be watching an episode of The Magic School Bus or Bill Nye the Science Guy in class. Recycling and renewable resources have been important to us from the moment we first learned about terms like energy and conservation. Many college students interested in the sciences would say that their early science classes are what inspired them to continue to study science in the future. Science education is integral to any primary school experience.

However, the future of primary school science education is uncertain. When teachers are overwhelmed with standardized testing and preparation in reading and math (science is not tested until the 5th grade in Ohio), science is the first subject dropped from the school day. Many teachers complain about lack of training on how to teach subjects like basic geology and physics. To combat this, many school districts provide science kits with materials for various hands-on science activities from companies such as FOSS and Scott Foresman. These companies profit from their fun and easy-to-use kits which include most required materials for in class activities. For example, the kit introducing electrical circuitry would include insulated wires, switches and light bulbs. However, the teacher is often unable to find the time to learn how to use these kits.

"They provide in-service days in which we are supposed to learn how to use these kits, but at the same time, we are given all kinds of [test prep and grading] we are supposed to do. There's no time," says one 5th grade teacher in an underfunded school district in central Arizona.

That isn't to say that science is disappearing from schools. According to Ohio's New Learning Standards, science is still a part of the vision and goals of education. For each grade level, in the categories of "Earth and Space Science," "Physical Science" and "Life Science," but teachers are expected to fit all of this information into a school day with little administrative support. This leads to lower quality in the education. When there is time in the day to get to science, an overwhelming amount of information needs to be fit into the lesson in order to meet these standards. The quality of science education is dependant on teachers being given enough time in the day, the training, and administrative support. We often hear that with less focus on standardized testing and more attention on classroom learning, schools would be more successful, but action needs to be taken by lawmakers, administrators and parents alike. The next generation of engineers, researchers, doctors and science enthusiasts depends on it.

Increased Lightning

How Man-made Airborne Particles are Effecting Extreme Weather Events Over the Amazon Basin

By Natalie Pierson

Lightning over an Amazon rainforest region has been increasing due to smoke and airborne waste from nearby agricultural and industrial practices, according to a recent study.

Scientists previously believed that lightning was influenced only by other meteorological events, but a study by cloud physicist Tianle Yuan of NASA's Goddard Space Flight Center in Greenbelt, Maryland, found human activity that releases aerosols can affect lightning frequency. The research will be presented in June at the annual meeting of the American Meteorological

Society.

Lightning is generated by cumulonimbus storm clouds, called deep convective clouds. In order for lightning to occur, two different-sized ice particles must collide and transfer electric charge. Whether something as small as anthropogenic aerosols—roughly one micron in size—could affect the deep convective clouds, or the lightning it produces, has been a debate among cloud scientists. According to Yuan, the Amazon Basin serves as an ideal model for studying the impacts of aerosols on lightning.

The Amazon region is roughly the size of the contiguous United States, but, while the weather from Florida to Washington State varies, the weather of the Amazon is more consistent. As a result of this meteorological uniformity, changes in the weather of one area will stand out. This allows scientists like Yuan to observe particular areas with agricultural and industrial activity, and to study whether these aerosol events are having a significant impact on the atmosphere and meteorology above the rainforest.

In the region Yuan studies, farmers cut down trees to grow crops. To dispose of the cleared vegetation and the remnants from crop harvests, the farmers burn them during the dry season. "That creates a lot of particles," says Yuan. "At the same time, dry air tends to create more lightning. Then it becomes a question: is it really the aerosols that are affecting the lightning? Or is it just the dry air?" By comparing it to similar Amazon regions where vegetation burning does not occur, however, Yuan and his colleagues can pick up on subtle and specific differences in the weather.

Yuan and his team used NASA Satellites and data models to collect data. The instruments used were Tropical Rainfall Measuring Mission (TRMM), Moderate Resolution Imaging Spectroradiometer (MODIS) and data model, Modern Era Retrospective Analysis (MERRA). To collect information about the nature of the anthropogenic aerosols, MODIS was used to take images of the Earth in different light spectrums, from visible to infrared. From these images, Yuan and his team derived the aerosol optical depth, a measure of how much light gets absorbed by the particles. Aerosol optical depth actually measures the light itself which allows one to extrapolate the number of particles in the air.

Methods for measuring lightning frequency were similar. TRMM is equipped with an instrument called the Lightning Imaging Sensor (LIS). This instrument scans the Earth, looking for a specific wavelength of light associated with lightning. The data model MERRA was used to analyze the past and current meteorological environment of the Amazon region. Data collected and generated from these sources were compared with each other, yielding the results that will soon be presented at the American Meteorological Society.

According to Yuan, on average, lightning increases 150% per 60% increase of aerosol optical depth. The results of this study demonstrate how human activities can influence an environmental phenomenon—lightning—thought to be too big and too complex for humans to change drastically. "Lightning is sort of an indicator for strong weather events, like strong precipitation and strong wind," Yuan said. Though this is not the climate change that we tend to think of, lightning can be an important measure for tracking long-term changes in weather patterns.

GMOs

Nate Bohm-Levine

Panic in the Midwest

The Ogallala Aquifer is drying out. This expansive Midwestern water source sustains most of the United States' wheat supply, and its levels are dropping fast. In recent years, severe drought has depleted the region, alarming many farmers who rely on consistent rainfall for wheat production levels. If the aquifer dries out completely, farmers will have to dramatically change their farming practices, and many families will be forced to adjust to higher-priced wheat.

But what if we could grow wheat that didn't need as much water? Here's where genetically modified organisms (GMOs) come in. The world's largest agricultural companies are currently producing strains of plants with increased drought resistance; one of these is a genetically modified (GM) corn plant that absorbs water more efficiently than unmodified strains of the same corn. If the same research is applied to developing strains of drought-resistant wheat, farmers could increase their revenue and the Ogallala Aquifer could retain its water, keeping a potential food crisis at bay.

The crucial role GMOs could play is not limited to midwestern wheat. With climate change and growing population threatening global food supplies, many see genetic modification as a crucial tool to mitigate these threats. Yet issues relating to GMOs are controversial, inciting explosive dialogue between scientists, government legislators, and natural-food advocates. Unfortunately, the general public has a weak grasp on the science surrounding this polarizing issue, leaving many without much choice — they ultimately align with whomever speaks loudest, or worse, make their decisions out of desperation and fear. This article will take you through the basics of genetic modification and present some the technology's biggest concerns, legitimizing its existence and its role in solving our current crises, hopefully dismantling some of the myths surrounding GMOs.

What is a GMO?

Genetic modification (GM) is the artificial alteration of an organism's genome in order to emphasize one of its desired traits. This can be done in two main ways—by selectively breeding an organism in order to elicit changes in its phenotype, or by directly changing an organism's DNA, known as genetic engineering. Humans have been genetically modifying crops for thousands of years using the former method—in a process called artificial selection. In this process, breeders select animals or plants that exhibit desired levels of a specific trait, and crossbreed these two organisms to eventually cause an entire population to express this desired trait. Using the latter method, genetic engineering, scientists can alter traits of an organism by very precisely engineering changes in its DNA. A GMO is any organism treated with one of the above techniques.

Let's take look at wheat. Wheat is a human-created hybrid that has evolved over many years of cultivation to form the several-species crossbreed we recognize today. In order to genetically modify wheat, sections of the plant are first placed in a dish full of nutrient-containing medium. Bacteria are added that have had their DNA altered to code for the desired gene modification — let's say pesticide resistance. The wheat soaks up the bacteria, incorporating the bacterial genome into theirs. If treated carefully, the wheat sections can be coaxed into growing roots. Once mature, this wheat will express the altered gene, which codes for certain proteins that block a pesticide from harming it in any way.

1994 saw the release of the first GM food product: Flavr Savr tomatoes, altered in a way that lengthens ripening time, increases shelf life, and retains flavor. Today, genetic modification has many forms: "Roundup Ready" corn has increased resistance to glyphosate pesticides (Roundup). Bt cotton expresses a protein that is poisonous to certain insects but harmless to humans. Golden rice produces higher levels of beta-carotene, a precursor to vitamin A. This is especially relevant to the developing world, where 1-2 million people die every year due to high levels of vitamin A deficiency (World Health Organization). Golden rice could prove to be an extremely helpful dietary supplement in these regions.

To this date, no GM wheat has been available to the public, despite a decade of research into drought-resistant, pest-resistant, and heat-tolerant plants. A drought-resistant corn strain has been released to the commercial market, but the release of GM wheat has met roadblocks from critics who still deem safety testing unsatisfactory and its impact on health unknown.

GMOs and Health

So what exactly are critics worried about? Naturally, altering our food should call for a certain degree of precaution and speculation. Yet study after study in non-human animals seems to confirm that GM food causes no observable harm to our health.

But in September 2012, this confidence in GMO safety was shaken. Gilles-Eric Séralini fed one group of rats entirely on GM corn, and another group with GM-free products. This experiment lasted two years (the lifespan of a rat), and by the end of the experiment, Séralini discovered something startling: the rats

in the GM group had developed significantly more cancer-related tumors than rats in the control group. Published in the journal Food & Chemical Toxicology, Séralini's results were the first of their kind—here was a study in a peer-reviewed journal that apparently linked GMOs to cancer.

Within 24 hours of the article's publishing, thousands of scientists and media groups responded, mostly with criticisms of the paper's experimental methods and statistical clout. One especially startling piece of information was that the strain of rats used, Sprague-Dawley, is known for its already high incidence of tumors. So to separate any statistical "noise" in experiments that measure rates of tumor incidence, it is recommended to use at least fifty rats per experimental group—Séralini only used ten. This leads to the possibility that any difference between groups exists due to random chance, not due to feeding methods. Others criticized Séralini, who was also the founder of the vocally anti-GMO advocacy group CRIIGEN, of approaching the study with a bias towards results that agreed with his organization's agenda—a big "no-no" in science. Eventually, all the criticisms of the article and Séralini's refusal to voluntarily pull his paper out of the journal led Food & Chemical Toxicology to retract the paper one year later.

So if Séralini's study represents the one piece of evidence against GMO health safety, and it was redacted, does that mean GMOs are safe? Not necessarily. Studies on non-human animals cannot always properly represent complex human biological systems, and many of these studies only address immediate health concerns while neglecting potential long-term health issues. When you conduct a long-term study on human health, you need to first amass a group of participants large enough and design an experiment long enough to demonstrate significant results. You also need a strong control group; in this case a group where every single participant would abstain from consuming any GMO products throughout the course of the study, to compare and contrast any effects seen in the GMO group of interest. But how can you really ensure this today, when in the US, 90 percent of corn and soybean crops are genetically modified? (MIT Technology Review). In other words, a robust control group free of any GMO exposure is a near impossibility.

If the prospect of any real epidemiological studies relating human health to GMOs seems grim, there is good news: we have unwittingly been a part of the largest experiment yet on human health. In the twenty years since the first GM product was released, there have been no noticeable detriments to our health from GM food consumption. But GM food critics are not only concerned with human health.

GMOs and the Environment

Both scientists and non-scientists are interested in the effects GMOs have on their surrounding ecosystem. Take for example, the relationship between cotton and the monarch butterfly. In 1999, the journal Nature published an article that correlated the rise of GM cotton plants expressing Bt (a natural insecticidal bacteria) to lower counts of milkweed, an essential food source for monarch butterflies. It is now understood, however, that the issue of disappearing monarchs is much more complicated than was first assumed. For example, it has been found that drought and other bad weather has decimated the monarch population over recent years, while other studies report correlated impacts due to illegal logging. An increase in pesticides plays a role not only in the monarch's decline, but also in the decline of bees and other pollinators (New York Times, "Setting the Table for a Regal Butterfly Comeback"). In other words, if GMOs play any role in the decline of the monarch butterfly, it is only a piece of a much more complex puzzle that researchers are far from having figured out.

A World with GMOs

Whatever our opinions on GMOs, it is too late to say that that we can live without them. Many of the country's largest crops are genetically modified; ingestion at some point or another of GM corn is practically inevitable. Agricultural companies and governments are in no position to slow down GMO research, since everyone involved benefits: companies sell GM seeds to farmers, who then experience increased crop yield and higher profit margins. This is because GMOs use less pesticides and fertilizer, making it easier for farmers to spend less while bringing in more. GMOs that provide additional nutritional supplements or extend ripening are beneficial to non-farmers as well, and these types of modifications may become increasingly necessary in the future. But as much as a drought-resistant wheat plant may quash concerns in the Midwest, questions still remain on the long-term impacts of GMOs on the environment and, some believe, on aspects of human health. Not to mention the ethical concerns of gene patenting, the corporatization of the agricultural industry, and the labeling of GMO-containing products—all of which are complex issues that I don't have space to tackle here.

But in a nutshell: GM foods have no morals. The biotechnological techniques of genetic engineering are neither inherently good nor bad—they're tools to solve problems that have puzzled humanity for millennia: how do we feed a growing population? How do we make the most of limited resources? And how do we maintain a healthy population amidst a growing need for efficiency? To answer these questions, we need skepticism and creative thinking—not fear-based decision-making.

Induced Pluripotent Stem Cells

Martin Mancini

Stem cells. At some point, you, my dear reader, have probably heard of them. I do not exaggerate when I say that, without them, you, and I, and most everybody on this little planet of ours would not be here. So if indeed you have heard of them, I give you a standing ovation, good reader. I am pleased.

Pleased as I am, however, I confess I don't quite know what, and how much, you have heard. It could, for all I know, be nonsense. But that's okay. I am not here to make you into a leader in the field of stem cell biology. I can't. I'm just here to tell you about something cool: induced pluripotent stem cells.

Induced pluripotent stem cells, or iPSCs as they are often called, are not your standard embryonic stem cells, or ESCs. In both morphology and biochemistry, the two are indeed quite similar, but, in terms of origin, they are not the same. Simply put, iPSCs are derived from somatic cells.

And the process for deriving them, referred to as reprogramming, is rather simple. It begins with packaging in viral vectors a set of four genes—Oct4, Sox2, c-Myc, and Klf4—that encode transcription factors important in pluripotency. In a process referred to as transduction, those viral vectors then enter the targeted somatic cells, and initiate the process of expressing their genetic cargo.

To those of you not acquainted with molecular biology, the paragraph above may seem like a lot. So massage your temples; consider its meaning; like Cosmo Kramer, you may feel inclined to shout "serenity now!" Feeling better? Good. Let's get back to it.

Now, it takes a while for the cells transduced with the four genes listed above, commonly referred to as Yamanaka factors, to appreciably change. A few weeks, in my experience, is pretty typical. But once they change, they change significantly. The cells become tighter and more compact. Their colonies develop a certain three-dimensionality under a microscope. And when immunostained for pluripotency markers, proteins that are highly expressed in pluripotent cells, they light up just like their embryonic counterparts.

That is not to say that all cells in a culture dish will reprogram successfully. On the contrary, reprogramming efficiency is often in the range of one percent. But some cells do reprogram, and if you can identify them in culture, and have the skill to manually transfer them to another culture dish, you can get cell cultures with fairly high percentages of iPSCs.

And that's when things start to get exciting. You see, if you have a decent number of iPSCs, you can begin to guide their differentiation.

That process is complicated and varied. The differentiation factors you would use to develop a cortical neuron are quite different from the ones you would use to create, say, a cell of the parathyroid. But it suffices to say that if you can guide cell differentiation, you can develop tissues. If you can develop tissues, you might just be able to develop transplants. And if you can develop transplants, you might just be able to treat disease in a new and powerful way.

Socializing with Scientists

Socializing with Scientists
Who: Faculty, Staff, Students
When: Every Friday, 5:30 pm
Where: Meet at southern entrance of Science Center, walk to Magpie's Pizza

As fledgling scientists we can often become caught up in the popular misconception that science is an austere and cold beast, demanding our ceaseless attention and mental energy. Constant lectures, assignments and lab work can drain the enthusiasm of even the most stoic intellectual, reducing one to a automaton that, much like kinesin's tireless journey across microtubules, is powered by sheer force of will (and ATP).

But my friends, my fellow scientists! Remember that nothing stimulates your mesolimbic pathway quite like the pursuit of objective truth, of lifting the veil between ourselves and the mysteries of the natural world, and sharing in the these discoveries with our colleagues.

Do not allow yourself to be ensnared in the daily ritual of academia and lose sight of the reason for which you study so diligently, and certainly never allow that passion for knowledge to slip through your fingers like ions through a beta barrel. I encourage you to seek out those outlets that remind you of these principles, and, if you are not sure where to begin, then I encourage you to come to Socializing with Scientists, where students and faculty come together to talk about what they love: Science!

Solitary Confinement

By Connor McClesky

In 1829, the Pennsylvania state government unveiled a revolutionary method of housing and rehabilitating prisoners known as the "Pennsy lvania System." This system, strongly influenced by Quaker theology , imposed complete isolation on the inmates, believing that the solitude and introspection would lead to repentance. The method spread throughout American prisons, rapidly becoming a tourist attraction for many foreign dignitaries and authors. Everyone from Alexis de Tocqueville to Charles Dickens visited the prisons to marvel at their design, as more and more European systems implemented the system.

However, within a few years, prison administrators began to notice a series of odd behaviors in the isolated inmates, observing previously docile prisoners would suffer "psychotic episodes" after prolonged solitude. Dickens noted the men seemed "dead to everything but torturing anxieties and horrible despair." Though the Pennsylvania System quickly faded out of popularity, it had a profound effect on American prisons: solitary confinement was here to stay.

Though it has evolved, the modern-day practice of solitary confinement (or "administrative segregation," as many prisons refer to it) in American prisons bears much in common with the Pennsylvania System. In the Pelican Bay Prison Complex in California, hundreds of inmates remain in complete isolation for up to 23 hours a day, each confined to a concrete cell measuring less than 80 square feet. In order to ensure the safety of the prisoners, personal possessions and books are not allowed. Inmates are entitled to an hour per day alone in the "yard," a small, empty concrete area ostensibly for exercise. At a "supermax" federal penitentiary in Colorado, prisoners reported being woken up every hour throughout the night by guards shining flashlights in their faces. Prison officials justify many of these abuses as necessary to ensure prisoner safety.

Contrary to what many believe, most of the inmates housed in solitary confinement are not Hannibal Lector-style super villains who pose too great a danger to society to be housed in normal facilities. Inmates can be placed in isolation for offenses as minor as talking back to a guard, or for refusing to take medication. In fact, many of the prisoners in isolation in the prison at Riker's Island are just juveniles, some who have not even been formally charged with a crime. Outside observers have recorded cases of inmates as young as 17 spending over 200 days in continuous segregation.

Today, the United States is estimated to hold anywhere from 20,000 to 80,000 inmates in solitary confinement at any given time, more than the rest of the world combined. More troubling, most states allow juveniles and inmates with mental illness to be subjected to prolonged solitary confinement, often under the guise of protecting fellow inmates and prison staff. Some inmates have spent up to 40 years in continuous solitary confinement, deprived of their rights to family visits and other resources. The United States is the only industrialized country in the world that regularly places juveniles and mentally ill individuals in prolonged isolation. In 1990, 193 nations were party to the UN Convention on the Rights of the Child, which forbade the solitary confinement of juveniles, declaring it to be cruel and unusual punishment, verging on torture. South Sudan, Somalia, and the United States are the only countries that have yet to ratify this treaty. The UN Special Rapporteur on Torture has repeatedly called for the prohibition of solitary confinement, stating that forced isolation for more than 15 days constitutes torture.

Since the beginning of the practice in the 1800's, the mental health effects of prolonged solitary confinement have been well known. German doctors studying prisoners began to notice a predictable pattern of mental disturbance in isolated individuals. Reports spread of isolation's "injurious effects on the body and mind," with doctors recording widespread hallucinations, aggressive tendencies, and attempts at self-harm amongst patients. One study concluded that half of the patients in the "insane department" of a German hospital were placed there due to "reactive manifestations" to solitary confinement.

> "The United States is the only industrialized country in the world that regularly places juveniles and mentally ill individuals in prolonged isolation."

Doctors today have an even better understanding of how damaging solitary confinement can be, particularly for juveniles or those with mental illness. Prisoners placed in solitary confinement exhibit mental illness at a far higher rate than the general population. An independent investigation in 2006 estimated that upwards of 60% of patients in secure units met the qualifications for "severe mental illness." A psychiatric study by the Commission on Safety and Abuse in America's Prisons of over 200 inmates in solitary noted a "strikingly consistent" series of symptoms proportional to the time spent in isolation. Researchers noted that for most inmates, "incarceration in solitary caused either severe exacerbation or recurrence of preexisting illness, or the appearance of an acute mental illness in individuals who had previously been free of any such illness." The study noted that over half of the inmates studied reported one or more of the following symptoms: hypersensitivity to noise and light, auditory and visual hallucinations, deficits in concentration and memory, panic attacks, uncontrolled and unwanted thoughts and aggression, paranoia, and issues with impulse control.

Juveniles are at even greater risk of developing mental health issues in solitary confinement. Federal studies have repeatedly highlighted the dangers of segregation for developing youth. The US Department of Justice found that juveniles experience hallucinations, anxiety, and paranoia after only hours of isolation. Juvenile inmates are also at an extremely elevated risk of suicide, particularly during long periods of confinement. A report by the US Attorney General found that "among the suicides in juvenile facilities, 50% of the victims were in isolation at the time they took their own lives and 62% had been in solitary in the past. This report goes on to describe the case of a 16-year-old boy who had spent 180 days in solitary confinement. He had "self-mutilation scars too numerous to count." Despite wearing shackles and a "Ferguson gown" (a straitjacket consisting of 242 velcro strips), this boy was only permitted to meet with his lawyer under the supervision of three guards.

Recent activities by prison reform groups and other human rights organizations have brought solitary confinement to the forefront of the national conversation. In the summer of 2013, over 30,000 prisoners in the Pelican Bay Prison in California embarked on a 60-day hunger strike to bring attention to the harsh treatment that many have experienced as a result of the state's practices. In April 2014, California legislators authored a bill to bring the state in line with international standards for the treatment of prisoners. Additionally, Colorado, New York, and Massachusetts are all in the process of attempting to limit the use of solitary confinement, particularly among minors and the mentally ill. Though the US still lags far behind the world community in prison policies, these efforts show that there is hope for reform.

Recent advances by food scientists promise gluten-free breads that are more affordable, nutritious, and flavorful!

Against the Grain

by Dayna Gallagher & Jenn Feigin

Human beings have been eating gluten-containing wheat products for thousands of years. However, for the 1.8 million Americans with Celiac disease, the tiniest exposure to gluten can trigger an immune reaction powerful enough to cause extensive damage to the intestines. People with Celiac disease have to be alert around food all the times; they have to be able to spot potential hazards in common products and on restaurant menus. In recent studies, six percent of Americans reported that they regularly experience less-extreme version of digestive distress after eating glutinous foods, and thirty five percent of Americans said that they are trying to eradicate gluten from their daily food intake altogether. If you are one of the estimated 20 million gluten-sensitive Americans, you too might seek gluten-free alternatives to your lamented love, your beautiful betrayer– Bread.

Gluten is one of the most heavily produced, marketed, and consumed proteins on the planet. Most often, we encounter a concentrated form of gluten in bread, though it does pop up in surprising places (check your pickles!). The term "gluten" refers to proteins that occur naturally in wheat, rye, barley and hybrids of these grains. Gluten is formed when two water insoluble molecules (gliadin and glutenin) form a bond. Through the process of kneading dough, that bond creates an elastic membrane, which gives bread its chewy texture and allows chefs to toss and twist the dough. Gluten also traps CO2 , which adds volume to the bread loaf as it ferments.

For those with Celiac disease, gluten-free products are necessary alternatives to avoid the serious health risks of consuming gluten, including nutritional deficiencies, osteoporosis, and intestinal cancers. Though the risks of this disease only impact a portion of the total population, gluten-free alternatives have become popular with the larger consumer public. According to Mintel, a market research firm, gluten free products had total sales of $10.5 billion in 2013 and are expected to account for more than $15 billion in revenue by 2016. With everything from vodka to cookies being marketed as gluten free, there is some confusion over what exactly the term means.

In August 2013, the U.S. Food and Drug Administration (FDA) strictly defined the term "gluten free" and has mandated that in order to use the term "gluten-free" on its label, a food product must meet all of the requirements of the definition, including that it must contain less than 20 ppm of gluten. The rule also requires foods with the claims "no gluten," "free of gluten," and "without gluten" to meet the definition for "gluten-free." Food manufacturers have responded to this increased demand and stricter labelling, much to the delight of Celiac sufferers, by formulating a vast collection of gluten-free foods.

To address the gluten-free community's nutritional needs, food technologists seek to develop foods that are not only gluten-free, but similar in character to gluten-containing products. However, as O'Shea et al. (2014) point out in their survey of gluten-free research, the quality of these products is still notably lackluster. Although gluten-free alternatives are readily available on the shelves of many grocery stores, these products are often crumbly and brittle, and are perceived as being of inferior quality compared to the wheat products they aim to substitute. In addition to these deficits, gluten-free foods have also often been found be lacking in nutritional quality. They have been reported to contain lower levels of essential nutrients such as types of vitamin B, iron and fiber, than are found in wheat-containing products. This is mainly due to the fact that gluten-free products are generally formulated with starches and refined flours, and are not usually fortified. It's no wonder, then, that food scientists describe the gluten-free breads of the past as having a low volume, pale crust, and bland flavour. O'shea *et al*. discuss the recent advances in developing foods that are gluten-free, focusing on ingredients and processing methods documented to improve the processing characteristics and nutritional properties of gluten-free products.

According to the authors, research has addressed some of the nutritional needs of those with Celiac disease by formulating palatable, gluten-free breads with enhanced nutritional properties. Most have focused on using the so-called 'pseudo-cereals': amaranth, quinoa and buckwheat to replace wheat in bread formulations. "These cereals are gluten-free, and are also rich in nutrients; therefore, their incorporation in the gluten-free diet not only adds variety but improves nutritional quality."

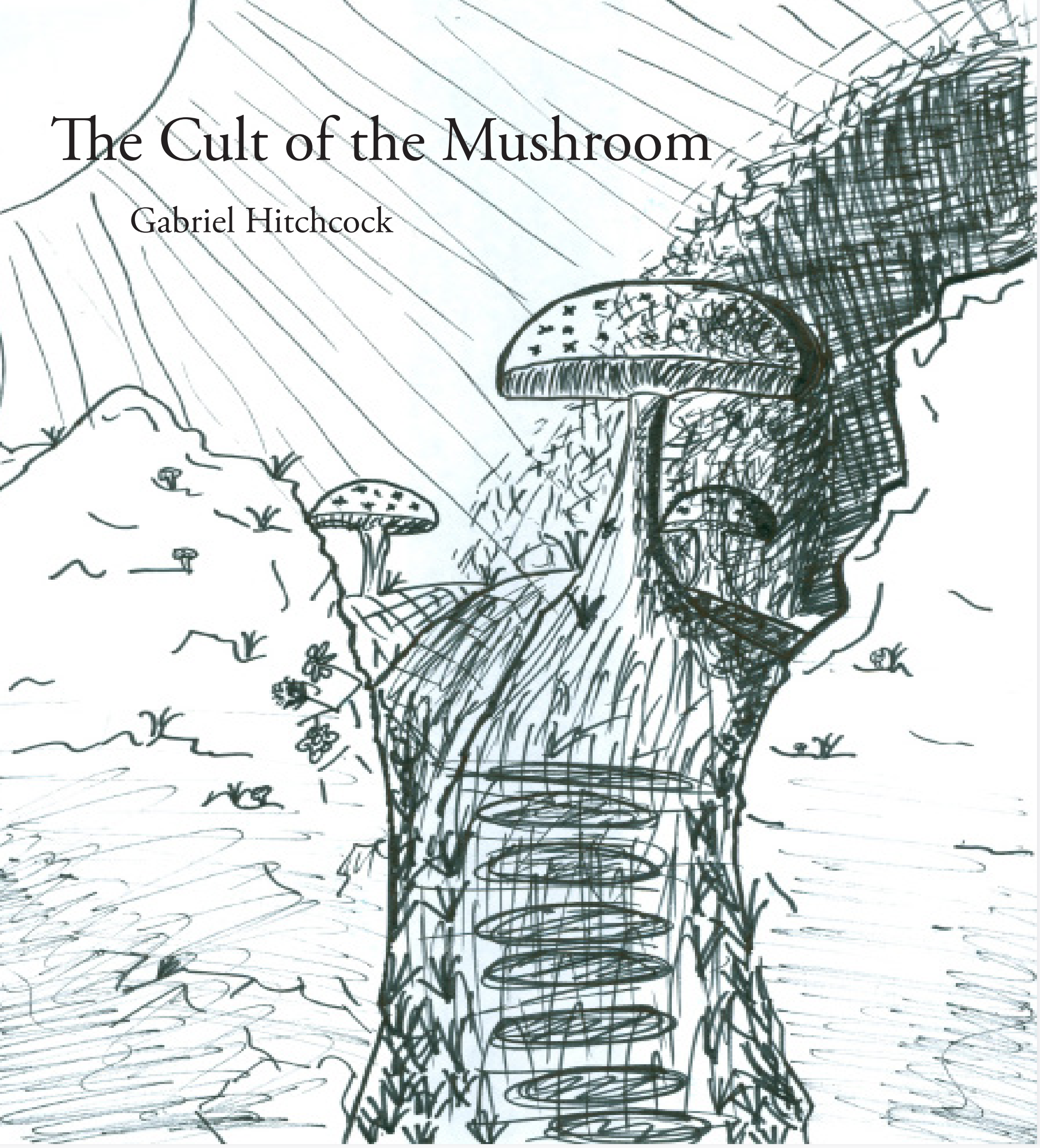
Another interesting approach makes use of lactic acid bacteria and yeasts (sourdough) as bio-processing ingredients in gluten-free formulations. According to O'Shea et al., "One potential benefit for gluten-free formulations is the sourdough starter's ability to generate enzymes (peptidase) with the capacity to detoxify wheat and rye peptides (responsible for the immune response developed from celiac disease);" this indicates the possibility of using cheaper, traditional flours in gluten-free baking. A second area of research that the articles covers, notes that lactic acid bacteria fermentation requires particular pH conditions which degrade phytic acid—an anti-nutritional factor known for binding essential minerals, such as, calcium, iron, and potassium—and the exploitation of this could increase the nutritional content of gluten-free breads. Additional conclusions in this area of research include: the growth of lactic acid bacteria controls the growth of any other organism present, increasing the shelf-life of the product; the inclusion of sourdough into a gluten-free formulation enhances the flavor profile of gluten-free bread; and certain lactic acid bacteria strains can produce long chain sugar polymers, which have the ability to act as a hydrocolloid replacements in gluten-free formulations, creating breads with a softer texture.

So far, however, the best approach to producing a bread of favorable baking characteristics from a highly "visco-elastic" gluten-free batter, research shows, is to use a combination of ingredients. Blends of chestnut flours, chia flours, and various hydrocolloids have had some success in replicating wheat flours. Other unique flours food scientists investigated include: carob germ flour, tiger-nut flour, lupin seed flour, and various vegetable flours. Scientists have examined additional ingredients to address common problems of gluten-free products, such as their inability to retain CO_2, dense crumb grain, and poor nutritional content. Supplementary ingredients include shortenings, whey proteins, and hydrocolloids, as well as calcium and iron.

Other scientists work with glutenin, the other important protein in wheat gluten. Not all glutenins, it turns out, are created equal. A team of chemists at The Bread Lab, part of the Washington State University-Mount Vernon Research Center plant breeding program are exploring the structure of glutenins of assorted molecular weights, shapes, and sizes. The research could help in the genetic engineering of glutenins that can outperform those of today.

The Cult of the Mushroom

Gabriel Hitchcock



But first, an etymological consideration:

> Some categorizations elude succinct definition. Not because they are inherently flawed, but because the categories themselves can become so convoluted and warped by time and circumstance that they take on a meaning all their own, thereby losing their objective utility. The word "cult" is one such term. Whatever notions you have about this word, whatever negative connotations you have garnered, you had better take a moment and rid yourself of them.

Done? Ok. Here is our new, unadulterated definition of a cult.

• Cult, n. A system of religious veneration and devotion directed toward a particular figure or object.

Nestled between the Sierra Madre mountains of the Guatemalan Highlands live many historically isolated tribes of Mayan people. The year is 1000 B.C. and, at this point in the Early Preclassic epoch, complex societal structures have begun to take their shape. These are the formative years of the Mayan civilization; the age during which they lay the foundation of the mighty empire to come.

Deep within this jungle, under the thick canopy, the only sound is that of dripping leaves and buzzing insects. Beams of light perforate the leaves overhead, slicing through the humid air and igniting the patches of vegetation they touch. A black form, its coat rippling from the protraction of its considerable musculature, moves slowly through the undergrowth, sidestepping the beams. The jaguar abruptly ceases its prowling and perks its ears at the unexpected crack of a snapped twig, its yellow eyes scanning the forest floor. Not far away, dark shapes move through the dense vegetation, their passage obvious to the keen sight of the giant cat. The creatures follow a twisted but well-worn path through the jungle that leads from their village to a neighboring tribe's. Rather than traditional spears and *macuahuitl*, these figures carry satchels packed with goods and trinkets for trade. These are the pioneers of what will soon become an industry of trade among the Mayan people. The jaguar, uninterested, slinks off into the shrubbery.

First raw materials such as obsidian, clay and herbs are exchanged between tribes. Later, as necessity demands, simple tools and weapons become desirous as communities continue to expand and complexify. Not long after, trade takes on a new commercial significance as demand for prestige goods and religious artifacts increases among tribal leaders. An economy is born and, from that, growth begins to flourish in many societal sectors. Stone blocks are crafted and stacked to create places of religion and state, a calendar is contrived in the Northwest,

obscure religious beliefs are melded into homogenous institutions, and mushrooms are venerated. That's right, mushrooms. While inhabitants of the neighboring Kaminalyuya settlement were busy building temples, enthroning emperors and establishing a sewage system, one tribe was producing mushroom-themed sculptures at a prolific rate.

It is no secret that early civilizations made a habit of aggrandizing natural entities to the status of gods. Most people have heard of Ra, the Egyptian god of the sun, or at least Apollo, his Greco-Roman counterpart. You may have even heard of Aranyani, the Hindu deity of forests or Perkele, the Finnish god of thunder, but you would be hard pressed to find a non-Mesoamerican culture that glorified fungus. I know; I tried.

There is something comforting in anthropomorphizing inexplicable occurrences. It gives someone to attribute

At this point we need a bit of biochemistry to set the stage for this argument.

Distributed throughout the human brain are chemical receptors called gamma-aminobutryic acid receptors (GABAAR) which, when bonded to by the proper molecule (agonist), result in hyperpolarization across the cellular membrane. That is to say, they produce an inhibitory effect on the neuron. Now, wide spread inhibition can have some fairly bizarre effects on the central nervous system (CNS), perhaps the most salient being auditory and visual hallucinations. Enter muscimol, the primary constituent of *Amanita muscaria*, the most likely model for our fungus-loving forbearers. Muscimol is a potent, selective GABAAR receptor agonist and altogether dissociative psychedelic compound. When consumed, muscimol passes easily through the blood brain barrier into the CNS. Similarly, many Psilocybe mushrooms contain considerable amounts of the serotonin-imitating psychotomimetic (psychosis-mimicking) constituent psilocybin. Psilocybin, while operating along a different biochemical pathway, produces a similar hallucinogenic state as muscimol.

The 70 year long study and classification of these myco-centric idols, as well as the research of the mushroom motif in Mesoamerican art, was done primarily by two researchers, a father and son. Dr. Stephan de Borhegyi, a Hungarian emigrant, discovered the "mushrooms stones" while cataloging the extensive collections of the Guatemalan National Museum in 1948. Though Dr. Borhegyi spent the remainder of his career dedicated to the study of the peculiar statues, his son, Carl de Borhegyi, completed the final analysis and subsequent publication. In his paper *Breaking the Mushroom Code: Mushroom Symbolism in Pre-Columbian Art* Borhegyi argues that the mushroom motif extends beyond the themed miniatures and is a ubiquitous symbol present in a myriad of Pre-Columbian artistic mediums. He goes on to posit that the inclusion of the motif is indicative of a culture that considered the mushroom, specifically *A. muscaria* and others of the genus Psilocybe, on a par with the ancestral Mayan gods.

In his blog Borhegyi writes:

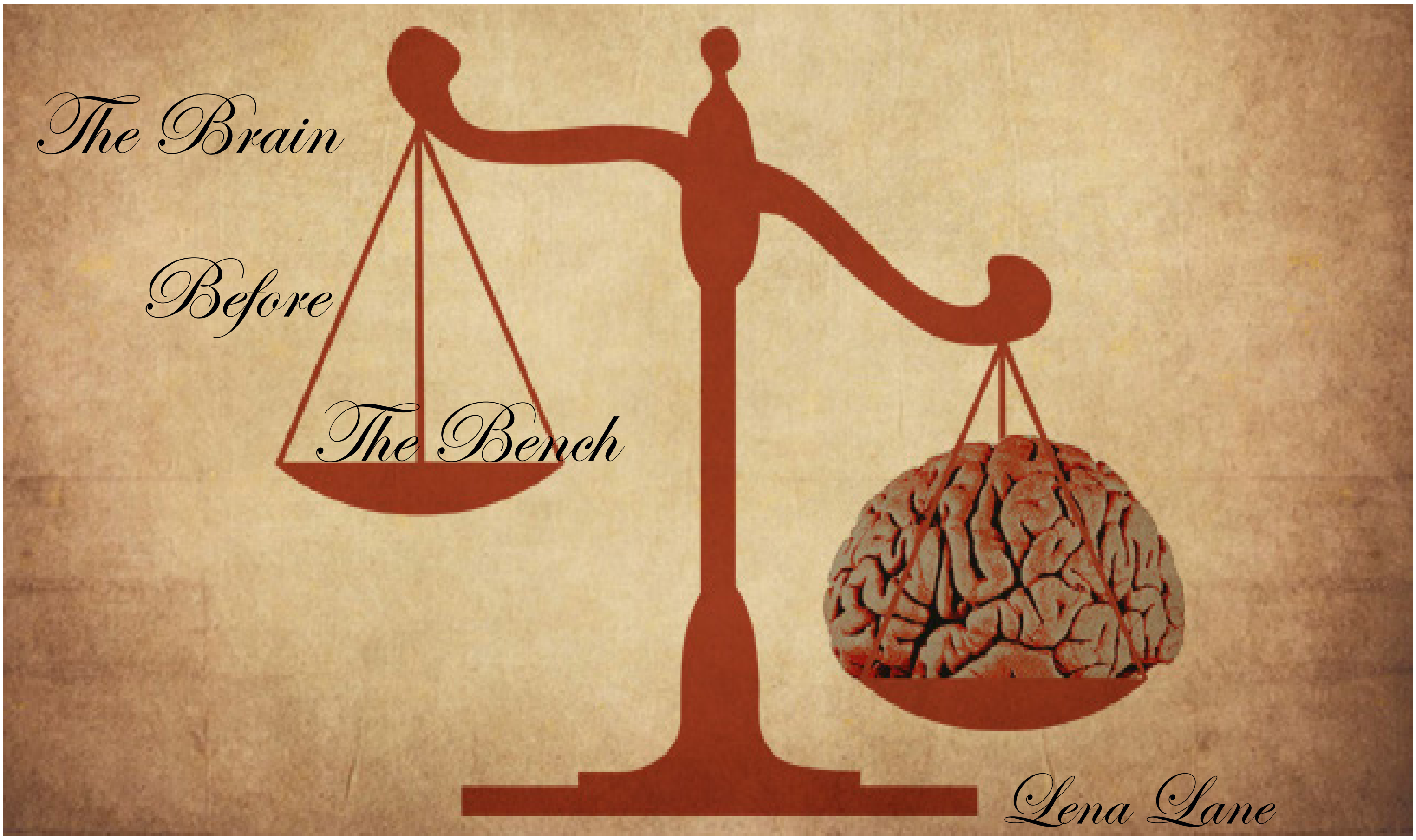
"The accidental ingestion of these hallucinogenic substances could very well have provided the spark that lifted the mind and imagination of these early humans above and beyond the mundane level of daily existence to contemplation of another reality. Mushrooms were so closely associated with death and underworld jaguar transformation and Venus resurrection that I conclude that they must have been believed to be the vehicle through which both occurred. They are also so closely associated with ritual decapitation, that their ingestion may have been considered essential to the ritual itself, whether in real life or symbolically in the underworld."

Entheogens are naturally derived chemical substances used in a religious, shamanist or spiritual context. Their use in ritualized contexts for the past thousands of years is indisputable, given strong historical and anthropological evidences. From the smoking of *Anadenanthera* beans in Argentina in 2130 BC, to the henbane tinctures (Herba Apollinaris) used by the priestesses of Apollo as early as the 8th c. BC, to the Salvia divinorum quids of early Mazatec shamans, mankind has been altering their collective consciousness for as long as they obtained it. These cultures, however, never venerated these substances in the same way that the Mayans did. To them, such compounds merely assisted in the opening of the gateway to spiritual transcendence,
but to these early Mesoamerican tribes the mushroom was the lock, key, hinges and frame of the gateway.

If you are skeptical of this take on Mesoamerican art then I challenge you: the next time you are
in a museum take a stroll into the Early South American art exhibit and look for yourself. I am confident you will not be displeased.

The Brain Before The Bench

Lena Lane



You are your brain. At least, over a century of cases demonstrate that when your brain changes, so do you — your personality, your proclivities, your capacity for rational decision-making, etc. Such was the case for Charles Whitman who, on the first of August 1966, climbed to the top of the clock tower on the University of Texas campus at Austin and began to shoot passerby indiscriminately; he killed 13 people and wounded 32 more before police were able to shoot him down. That morning, he killed both his mother and his wife. In his suicide note he expressed confusion about his condition, claiming that he had become a victim of irrational thoughts.

> "It was after much thought that I decided to kill my wife, Kathy, tonight… I love her dearly, and she has been as fine a wife to me as any man could ever hope to have. I cannot rationally pinpoint any specific reason for doing this…"

Whitman instructed that his brain be examined to determine the cause of his perplexing behavior. When the doctors extracted his brain, they discovered a nickel-sized tumor pressing on his amygdala, the center of the brain controlling fear and aggression. It was this tumor that most likely caused his violent shooting spree.

If Charles Whitman had lived and his tumor been removed, would we still convict him of murder? In law, defendants can invoke the "automaton defense," which posits: if you have, for example, some condition that causes your arm to fling uncontrollably and you happen to knock someone off of a cliff, you are not fully culpable for their death. In essence, it was your body, not you, that committed murder. Now this poses a tricky dilemma— should we consider a brain tumor to be an automaton? Does a person on drugs really know what he is doing? Can we ever separate someone's biology from who they are? Culpability, intent, and rationality are only a few of many subjects in the rapidly expanding field of Neurolaw.

Neurolaw is a multidisciplinary field that seeks to reconcile the law, which deals with human behavior, and neuroscience, which attempts to explain that behavior. Neurolaw reexamines the major question in our criminal court cases from that of intent, essentially distinguishing an individual's actions from their biology, which is often impossible, as we saw in Whitman's case. Neurolaw does not neglect intent or attempt to blindly exculpate criminals. Rather, it aims to locate a more rational method of sentencing, one that considers biology and uses that knowledge productively.

Sherrod Taylor coined the term Neurolaw in a paper published in 1991. This paper explained how advancing medical technology has led to survival of traumatic brain injuries and the need for neuroscientists and neuropsychologists in the courtrooms. In fact, Taylor writes, "more than two-thirds of all appellate court cases discussing neuropsychological evidence have appeared within the past 10 years!" Since the birth of Neurolaw, the Gruter Institute of Law and Behavioral Research, the Dana Foundation, and the MacArthur Foundation have contributed millions of dollars to the interdisciplinary field. Colleges have also started to create spaces to explore this field, such as the Initiative on Neuroscience and Law at Baylor College of Medicine and the creation of the world's first joint JD/PhD program in law and neuroscience at Vanderbilt University, the home of the MacArthur Foundation.

Neurolaw enables lawyers to reconsider basic assumptions in the law and make more informed decisions in the sentencing and rehabilitation of criminals. Neuroscience forces the law to reevaluate the assumption that everyone is equal before the law— no two brains are alike. This approach has implications for convicted individuals that share certain characteristics. For example, there is an assumption in law that all persons over the age of 18 should be tried as adults when these individuals may have much greater or less brain development than other people their age.

Not only are the assumptions underlying sentencing changing, but also the evidence used in the sentencing of criminals. One of the biggest technologies in cognitive neuroscience is fMRI. In 2010, fMRI or functional magnetic resonance imaging was used as a method of lie detection for the first time in court (United States v. Semrau 2010). It is a technology that permits us to look at blood flow to different brain areas as a proxy for brain activity while the individual is still alive and conscious. But there are many limitations to fMRI, such as the assumption that blood flow and oxygen usage means brain activity, especially when the defendant is asked questions retroactively. With new neuroscience technology, guilt will be put on a spectrum that gives the law a tool to recognize the uniqueness of each brain.

Neurolaw invites the legal system to re-imagine rehabilitation and the conception of jail as a one-size-fits all solution, or a de facto mental health facility. Neurolaw ponders whether criminals can be helped towards more pro-social behavior and how to restructure incentives to decrease likelihood of recidivism. One such form of rehabilitation is impulse-control. Long-term considerations versus short-term considerations are constantly at odds in our minds. This competition between different parts of your brain can be swayed towards long-term decision-making. The neuroscientists David Eagleman, Pearl Chiu, and Stephen LaConte have created a training routine that gives real-time visual feedback about brain activity through a bar representing craving, short-term decision making, etc. that it is the criminal's job to lower thereby giving them a physical object that they can work with as an avenue to training their mind. Making drug testing for drug addicts more frequent and the consequences for failure harsher and swifter is another means of restructuring incentives.

> "Neuroscience forces the law to reevaluate the assumption that everyone is equal before the law—no two brains are alike."

In the case of Jackson v. Hobbs (2012) and Miller v. Alabama (2012) the Supreme Court determined that juveniles convicted of murder couldn't be sentenced to life imprisonment without the possibility of parole. Rather, the child's character and life circumstances must also be taken into account when determining the sentence for a juvenile that has committed murder. The opinion cited scientific research about the development of the adolescent brain and their underdeveloped ability for long-term decision making that lessen a child's moral culpability. This marks a shift in judicial thinking about the differences between brains as well as taking into consideration that brains are not constant over time and that there is a chance for rehabilitation as a more viable option than life sentences in prison.

With the growing influence of neuroscience on the law, some believe that a great change will occur in law, others that question the extent of how much the law can change, and still others that worry about the possibility for misunderstandings of neuroscientists about law and of lawyers about neuroscience. Justice Ian Donald, the chairman of the British Columbia Court of Appeal's education committee, thinks that a profound change will happen in our conception of criminal responsibility. Peter McKnight, a writer for the Vancouver Sun argues our view of criminal responsibility will be slightly changed but that the real influence of neuroscience will be in sentencing and rehabilitation. People like Steven Erickson, a visiting professor at Widener Law, warn that neuroscientists must be careful to work within current legal framework rather than upending some of its basic foundations such as the assumption of responsibility. With growing use of neuroscience in courtrooms there is always danger in communicating across the divide between law and neuroscience disciplines. For Owen Jones of Vanderbilt Law School, avoiding misrepresentations of neuroscientific evidence depends on engagement of neuroscientists with many areas of law and support for more research in the area of Neurolaw.

Despite doubts, it cannot be denied that the rapid progression of neuroscience as a field has led to much enthusiasm for Neurolaw. Subjects in the field of Neurolaw cover more than just culpability and rehabilitation but also lie detection, memories, brain injuries, pain and distress, addiction, adolescence, judgment, brain death, and artificial intelligence. In years to come these subjects will give us new understandings of how our biology and decision-making coincide with the law.

Scientific Psychology: Why the Doubt?

Kevin Ng

Ever since the field's early days, psychology has drawn skepticism from people who question its scientific legitimacy. Arguably, a good deal of this skepticism comes from the historical influence of rightfully questionable ideas in the clinical domain, like Freudian psychoanalysis and phrenology. Contemporary psychological research hardly resembles those bizarre, early systems of thought, however. Ever since Wilhelm Wundt founded the first experimental psychology laboratory in the late 19th century, psychological research has become ever more rigorous. Nevertheless, many remain unconvinced that psychology, as a whole, is categorically on par with traditional sciences that have a longer history, such as chemistry or physics. Even as I walk around campus, I overhear students sneering at "BS" sciences like psychology. Some politicians go so far as to call psychology pseudoscience, or claim that funding should be stripped from behavioral and social science research. For example, Senator Tom Coburn of Oklahoma had already managed to block NSF funding for political science research in 2013. If the definition of science could so drastically affect a community's eligibility for research funds, then the question arises: what is science?

Philosophers have debated over the definition of science for millennium, and they have yet to agree upon a strict, concise definition. Solving the demarcation problem, as it's called, is a challenge that remains open to future philosophers. However, most of us practicing scientists do not have time to delve into a deep study of Philosophy of Science – Popper's falsificationism, Kuhn's Paradigm Shifts, or Post-positivist Theory. These strange phrases refer to philosophical frameworks which try to pinpoint what is essential to the scientific process. Falsificationism was developed by a Viennese philosopher named Karl Popper, who states that only ideas that can be shown to be wrong are to be considered scientifically meaningful (Popper went a bit further and said that, even if an idea has survived multiple attempts at falsification, our confidence in the idea should not be increased; we should just say it has not yet been falsified and no more than that). Another philosopher, Thomas Kuhn, emphasized the social aspects of the scientific enterprise; he said that scientific progress requires that scientists not question the fundamental ideas, or paradigm, of their field so that the field can have the chance to mature. However, when enough observed anomalies, or things that don not fit their guiding framework, accumulate, the basic ideas are back out onto the table for discussion in what is called a Paradigm Shift. After a new framework emerges from the chaos, science proceeds as usual. Post-positivism refers to a broad set of sociological ideas that critique the supposition that how scientists think and how common sense works are not different; Post-positivists tend to believe all observation is fallible and cannot be value-free, that scientific ideas are not independent of the social, economic, and political forces that surround it, and that science is actually the endeavor to reach the unattainable goal of acquiring truth without subjectivity.

Of course, these are gross generalizations of rather complex philosophies. Yet, to reiterate, few scientists have the time to dig deeper into these ideas on the basis of busy schedules – some may not even have the interest. It is therefore helpful to have a "rule of thumb" definition of science as something to reference in conversations, so that we don't stare with a blank face at the task of defining science. There are enough similarities across disciplines to allow at least some formulation of a working set of essential characteristics. Keith Stanovich, Professor of Applied Psychology at the University of Toronto and author of How to Think Straight About Psychology, offers such a definition. In his primer on critical thinking in psychology, he lays out three broad principles that define scientific inquiry.

1. Systematic empiricism
2. Public verifiability
3. Exploration of falsifiable hypotheses

The first is systematic empiricism. Many believe "empirical" means experimental, but it can actually mean something a bit broader than that. "Empirical" comes from the Latin transliteration of a Greek inflection of "empeiria", meaning "experience." This makes sense, since scientists rely on observation; we observe a phenomenon by experiencing it through one or more of our five senses. However, relying only on raw, unstructured experiences is not a sufficient condition, otherwise we would all be scientists all the time. Furthermore, writing down every observation you make from dawn till dusk will result in a huge list of facts at the end of the day, but it will not yield a more fundamental or generalizable understanding of the world. Scientists structure their observations so as to uncover something underlying about a phenomenon.

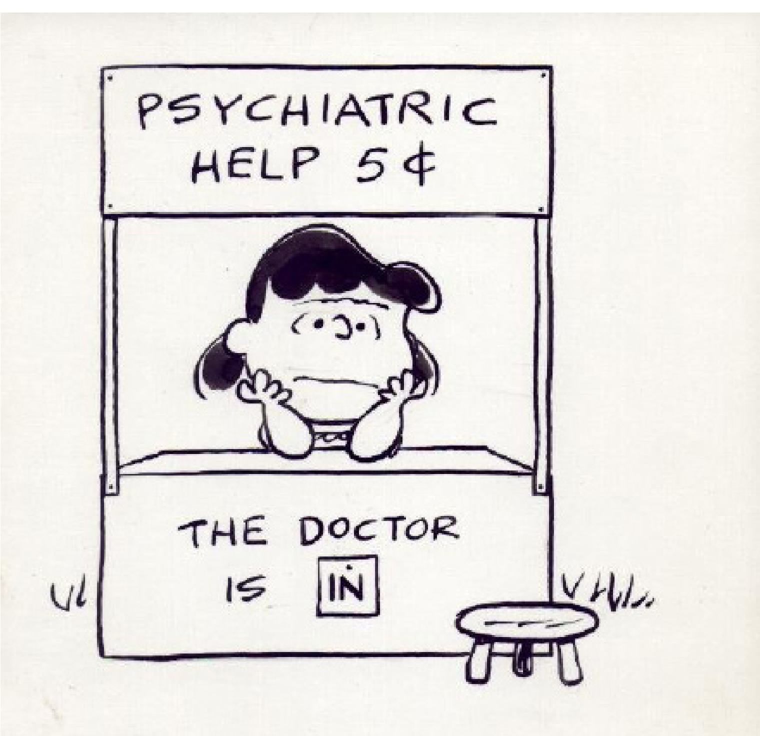
The second criterion is public verifiability. Ideas trapped inside the head of someone who drew conclusions from a study have little utility for the rest of the scientific community. They must be submitted to the scientific community for scrutiny, discussion, and criticism. Two mechanisms act as quality control for submitted information: peer review and replication. Peer review standards vary from journal to journal, and the open-access movement is adding a new dimension to it. Nonetheless, what is important is that information that has been vetted by peer review has met a minimal standard of scrutiny, even if it is not necessarily correct. Without some level of scrutiny by the relevant experts in the field, journals run the risk of blatant misinformation or baseless assertions being placed side-by-side corroborated claims. Peer review is not meant to be the final arbiter of what is true and what is not; it is simply intended to make sure that well-supported ideas propagate through the field. Replicating studies is what enables scientists to sort out the true findings from the spurious ones. It gives other researchers a way to make sure a certain finding was not the result of the biases or errors of a particular set of scientists.

Continued from page 15

The third criterion is the exploration of falsifiable hypotheses. Scientists address ideas that can produce confirming or damning evidence. If a theory poses certain hypotheses, and those hypotheses consistently fail to be supported, then the theory should be either adjusted or discarded. Either way, it has been falsified. This is a good thing; consistent failures to fulfill predictions mean that certain ideas are being supported while others are not. While we can't be absolutely certain in this process of elimination, it does free us from having to be equally open-minded to all empirical claims. Scientific theories need to be presented such that they can be shown to be wrong. However, the boundary between the falsifiable and the unfalsifiable can be blurry; as empirical methods improve, questions can drift into the scientific domain. For example, many years ago, historians believed that there was no way to figure out whether or not Thomas Jefferson was the father of a mixed-race slave boy. As the field of Genetics became more technologically advanced, however, the question gradually became recognized as testable. By the end of the 20th century, knowledge about DNA and genetic technology advanced to the point where methods for verifying bloodlines were available, and Jefferson's fatherhood status had confirming evidence at last.

Given Stanovich's "rule of thumb" definition of science, how does psychology fare? There is definitely systematic empiricism, ranging from case reports to controlled trials. Psychologists also conduct correlational studies, which are less rigorous than experimental studies, but they are still a form of data collected from structured observations. Astronomy is an example of a science where controlled experiments can be rare – it is rather impossible to experimentally manipulate asteroids or supernovae. There are also a great number of peer-reviewed psychology journals, a reflection of the diversity of topics the field covers.

An interesting issue comes up with regard to falsifiability and replication. In November of 2012, the journal Perspectives on Psychological Science published a series of articles



addressing a "crisis of replication" in psychology. Many were concerned that replication studies did not occur often enough in many of psychology's sub-fields. This is problematic, because replication is one of the classic mechanisms of science by which false findings are filtered out from the true findings. In one review, researchers tried approximating the number of replication studies in the field by searching the publication history of 100 high-impact psychology journals for the stem "replicat-". Only 1.6% of journal articles in the search had the stem; an even smaller percentage of that 1.6% were verified as actual replications. The authors note that psychology is not alone in this regard, as other studies found similar replication rates in other fields, like business and certain medical subfields. There are many likely contributors to why replication studies may not occur in a field, including lack of funding, differences in what research is prioritized, differences in academic incentives, etc. A change in any one of these contributors might lead to a change in how psychology is practiced. That is, if funding agencies recognized the value of psychological research, they might provide more funding, which would lead to more studies overall and perhaps a higher percentage of replication studies. If the academic culture shifted to incentivize repeating other researchers' work, the practice of psychological research might entail direct replication studies more regularly. A change in the cultural norms of the practice of conducting research may be what it takes to get more replication happening in these fields.

Another issue that is hardly restricted to psychology is the problem of publication bias. In 1959, a statistician named Theodore Sterling was looking at fields that commonly used null hypothesis statistical significance testing and found that around 97% of a sample of four high-impact psychology journals reported positive, or statistically significant, findings. He explained that this was suspiciously large; even for actual phenomena, one expects at least some null findings, just by chance. Human behavior is probabilistic, so where were all the studies in which no relationship between variables was found? He did the same thing more than three decades later and still found a huge proportion of positive findings. Just five years ago, Daniele Fanelli did the same thing; he found psychological findings to be much more likely to be positive than findings in the natural sciences, though the social sciences in general seemed to exhibit a similar pattern.

In an academic culture where researchers feel the pressure to publish positive findings, and where no one is going to get tenure any time soon by reporting that nothing was found or repeating someone else's work, these results are hardly surprising. Yet the danger is eminent. A scientist can run a study once and find nothing, but if they run the same study 19 more times, then by chance one could give them a publishable, significant result. Random background noise in data will look like a pattern given enough shuffling and combinations. It is by trying to reproduce findings, and publishing both the times a theory worked out and the times it failed, that we can see how solid a theory is overall. If positive findings have a higher probability of being published than negative ones, then literature becomes biased samples.

It is by trying to reproduce findings, and publishing both the times a theory worked out and the times it failed, that we can see how solid a theory is overall.

There is reason to be optimistic. A number of online initiatives have sprung up to in order to address these problems, like the Open Science Framework. Furthermore, some journals are starting to recognize the trouble with pushing for novel, pioneering research. While psychology's "vast graveyard of undead theories", as one behavioral scientist put it, seems to be psychology's most legitimate criticism, a number of caricatured criticisms are more well-known. Keith Stanovich addresses a large number of them in How to Think Straight About Psychology, and Scott Lilienfeld, Professor of Psychology at Emory University, has also published about the more popular criticisms. Those will not be explored in depth here. Two of them are "Psychology is just common sense" and "Psychology cannot predict things exactly". A moment's thought about these claims reveals their lack of substance. Critical thinkers understand a variety of problems with relying on "common sense" as the arbiter of truth, and behavior is inherently too complicated to predict. Yet with the power of statistical methodologies, psychological researchers do predict human behavior at a rate much greater than chance. Medical researchers also use these methods, and cognitive neuroscientists use them in conjunction with some of the same experimental paradigms as cognitive psychology.

Human thought and behavior are far more complicated than anything you can fit in a test tube. Yet researchers who are interested in questions about humans do the best they can to apply scientific thinking to behavior, and for that, they should be applauded. The problems affecting hypothesis falsification and reproducibility should not be de-emphasized, of course; even my introductory psychology professor lamented the lack of replication studies in his field toward the end of the semester. The problem of non-publication of data and non-replication is not uniform in psychology; some subfields are more affected by it than others. Some have pointed to clinical psychology as faring the worst and cognitive psychology as faring the best. Looking at the big picture, if academia does not incentivize null results or reproduced work, then surely other fields of scientific inquiry will be affected; psychology is not in a unique situation. It was only through psychological researchers publishing articles about these problems that we are aware of them. Self-criticism is the first step to self-correction. In fact, any field that exhibits these principles would be called scientific. After all, science is a process, a way of thinking. If someone exhibits this way of thinking and engages in the process, then that person is a scientist. A scientist is a scientist, regardless of what else we happen to call the person: sociologist, economist, archaeologist or, of course, psychologist.

Our Curiosity Intensifies

The question is no longer if Mars could have supported life, but if it still can.

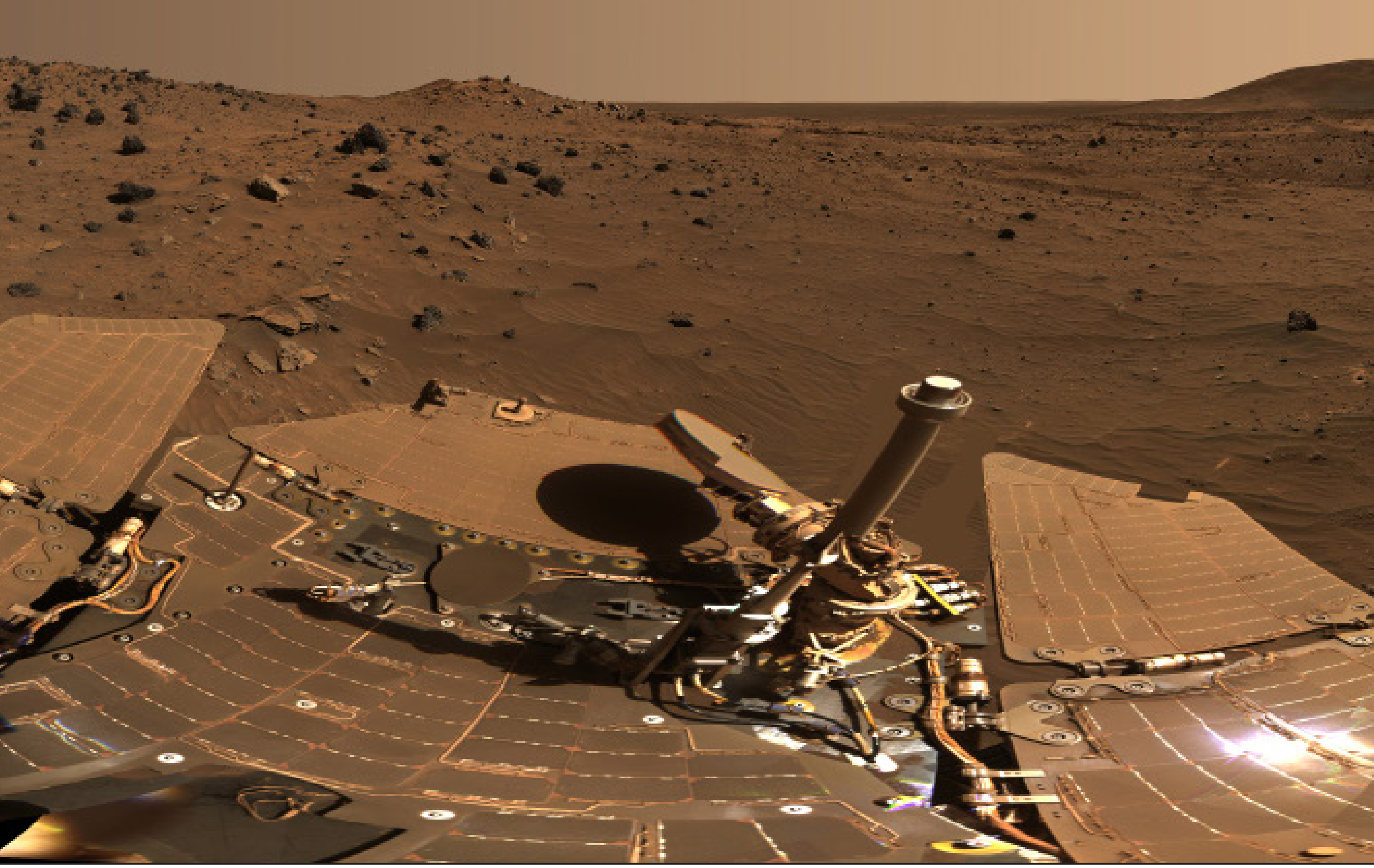
By Jacob Turner

Imagine a typical day on the surface of Mars. The temperature is somewhere between -200 and +100 degrees Fahrenheit, a few wispy clouds made of water-ice or carbon dioxide loom in sight. The surface is iron-red and rocky, resembling a large desert. Though the air is still and lifeless, there is movement. A robot the size of a car can be seen scanning the area, moving about on six wheels powered by the energy captured from the radioactive decay of plutonium dioxide. After stopping about 20 feet in front of a rock, the robot fires a laser and analyzes the chemical compounds from the resulting vapor. If it deems the rock worthy of further investigation, the robot will then drill into the rock for a more in-depth analysis of its chemical makeup. Such a scenario may sound like science fiction, but it is actually a description of everyday goings-on of Curiosity, an unmanned mobile laboratory and rover designed by NASA to better understand the history of Mars and whether or not it could sustain life. With each passing day, scientists are becoming more and more optimistic about such a possibility.

Curiosity is just the latest in a long line of Mars rovers painting an increasingly more detailed picture of what Mars is made of and how it has changed throughout its history. Understanding these two characteristics is crucial to concluding if Mars could be life sustaining. The implications of the data range from determining the safety and sustainability of a permanent Mars colony to answering the age-old questions of whether Earth is the only place in which life can exist or does exist. Previous rovers, such as the recent Spirit and Opportunity, discovered mineral compositions and rock formations that could only have formed in the presence of liquid water. However, the water would have been too acidic to drink. Regardless of that particular water's portability, the fact that there was evidence of liquid water at all was a huge step in understanding what Mars was like in its past and gave hope that liquid water may still exist on the planet's surface. Curiosity's mission is to expand on these discoveries.

Curiosity's landing spot was carefully chosen to ensure the highest likelihood that it would find valuable data. Using the Mars Orbiter, NASA decided to land Curiosity in Gale Crater, an area of Mars that probably once had water. Additionally, in the center of the crater there is a large buildup of rock layers known as Mount Sharp, which could be a remnant of a larger structure that existed on the site of the crater before it was hit with an asteroid between 3.5 and 3.8 billion years ago. Scientists believe that Mount Sharp could hold information about Mars' early history.

The tricky part was landing the rover. Older rovers entered the atmosphere in a capsule, which then opened a parachute to slow the descent. The rovers were then suspended from the capsule by wire and completely surrounded by air bags. After being released a few meters



above their destination, the rovers safely landed on the ground. The first part was doable, but Curiosity was simply too large and too delicate for the airbag technique to work. Instead it was deployed using what is called a sky crane. The rover entered the atmosphere the same way, but it was folded up inside what is called a descent stage. While hovering around 25 feet above the ground, the descent stage lowered Curiosity while the rover slowly unfolded all of its parts. Once Curiosity landed, the cords connecting the stage to the rover were cut and the stage flew away to crash land a safe distance from the rover. To make matters worse, the entire landing sequence had to automated, because the signal from the rover to Earth would have taken too long for a safe, manual landing.

Curiosity has also found evidence of ancient riverbeds, evidenced by rock formations, smoothed stones, and sediment deposits that only form in the presence of flowing water.

Since landing in Gale Crater back in August of 2012, Curiosity has made some incredible discoveries providing evidence of a Mars that could have been a much more Earth-like place. Within the first few days of its mission, Curiosity, using a tool called the Sample Analysis at Mars, or (SAM), determined that Mars' early atmosphere may have been very similar to present-day Earth. Due to bombardment by high-energy, charged particles ejected from the sun called "solar winds," however, this atmosphere has slowly eroded over time. Curiosity has also found evidence of ancient riverbeds, evidenced by rock formations, smoothed stones, and sediment deposits that only form in the presence of flowing water. The mineral composition of these rocks indicates that the water would have been much more pH-neutral than earlier samples from other locations. After drilling into nearby rocks, Curiosity found that they contained what are considered the six most important elements for life: oxygen, hydrogen, carbon, sulfur, phosphorus, and nitrogen. Using the collected data, scientists at NASA have concluded that this area would have been suitable for microbial life to thrive. Such conditions have also been found in the remains of a 3.5 billion year old lake on Mars. However, in what may be the most exciting discovery yet, Curiosity has determined that Martian soil is uniformly 2% water. Such a discovery strengthens the current hypotheses that Mars still has underground water sources, where microbial life could still exist. The answers to these speculations may become the goals of future Mars missions.

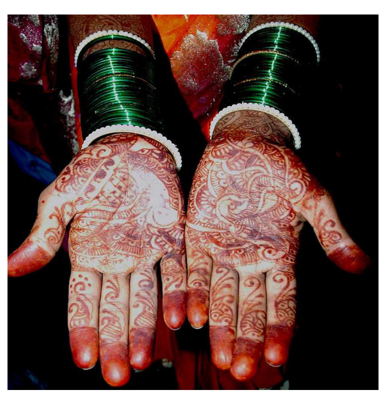
Today, Curiosity is still going strong and currently heading towards the base of Mount Sharp, where it hopes to find clues to the different chapters of Mars' history. With all of the amazing information already uncovered, it is exciting to think of what Curiosity may discover in the years to come.

THE EVOLUTION OF TATTOOS

Revolutionizing One of Humanity's Oldest Art Forms

By Marisa Atkins

There are many ideas, concepts and objects that have been around for thousands of years. Most of these you hear about in class, but there are some topics that aren't normally discussed. Perhaps they are taboo or not particularly understood. One of those topics is tattoos.



The original purpose and age of tattoos is unknown to most people. The oldest reported tattoos date back from 5000 to 4000 BC. They were found on "Otzi the Iceman" who was uncovered in the Alps by two German tourists. When Otzi was recovered and studied, archeologists found sixty-one tattoos ranging over his body. The tattoos are grouped and shaped similar to acupuncture marks, leading historians to believe they were used as a type of healing device. Although Otzi's tattoos are hypothesized to be for medicinal purposes, a sign of age and rank, or recreation are also theories fitting the time period.

The evolution of tattoos is an abnormal topic to discuss, but one should always explore the unexplored. Tattoos are a part of our cultural history and are leading to promising technological advances in the future. As such, this article discusses some of the most interesting aspects of tattoos: ink; the body before, during, and after; and how tattoos have become a tool for science.

There have been many types of inks used to produce tattoos. The ink used in Otzi's tattoos was carbon based, specifically soot. Archeologists are unsure how he managed to etch the soot into his skin, but one theory is that thorns were used to inject the soot. Another older type of ink is Henna. The ink used is from the Henna plant. In order to make Henna dye, one must grind up the leaves of the plant into a paste and mix with various ingredients for color specificity. This plant is native to tropical regions but can be grown at home with the necessary conditions of full sunlight and heat if you're interested in that sort of thing.

Modern dyes are more complex than their predecessors, but also much safer. Modern inks are composed of pigments suspended in a carrier solution. The pigments can be made from minerals, vegetable dyes, plastics, or most commonly, metallic salts. The purpose of the carrier solution is to keep the pigment evenly distributed, inhibit growth of pathogens, and prevent clumping. Some of the most popular carriers are ethanol, purified water, Listerine, and glycerin. This is the most important part of the ink and makes it safer than ancient inks such as Henna and soot.

Some of the most interesting modern inks used today include ultraviolet (UV) ink, vegan ink, and removable ink. UV tattoos are done using special ink that is invisible to the naked eye under regular lighting but glows under a black light. There is also colored UV ink, which is lighter than classic inks but visible under regular lighting. A UV ink molecule is encased in a polymer known as polymethylmethacrylate (PMMA), thus preventing the ink from coming into contact with the skin. This makes UV ink hypoallergenic and generally safer than most other inks, though no long term testing has been done to verify this since the time it takes the human body to break down the PMMA is unknown.

Vegan ink is one that most people are surprised to hear about. Why wouldn't ink be vegan, you might ask? Some inks contain animal by-products. For instance, black inks, like those used in Otzi's tattoos, can be made from charcoal, which may be formed from burnt animal bones. Or, the carrier glycerin can be made from animal fat. So for those of you who do practice veganism, make sure to check that your ink is made from an organic carrier and the pigment comes from minerals.

Removable ink is one of the most talked about inks, lately, even though it has been available for seven years. Dr. Rox Anderson, a professor of dermatology, and other scientists at Harvard invented removable ink in the late 90s. It is made up of dye and biodegradable plastic polymer casings. When the polymer encapsulates the dye, the ink is permanent. However when a laser strikes the biodegradable polymer, it combusts and the dye fragments are then released into the blood stream. Eventually, these fragments are passed out of the body. This tattoo removal treatment takes one laser treatment while the current process takes up to fifteen.

Now that the possible inks have been discussed, what happens to the body while receiving a tattoo? The body can experience a few different reactions. One reaction is pain, of course. Tattoos are implemented by a small needle grouping attached to a chamber of ink, known as a tattoo machine. Each ink dot is produced by the separate prick of a needle. Therefore, the bigger the tattoo, the more pain. This is true unless, of course, your

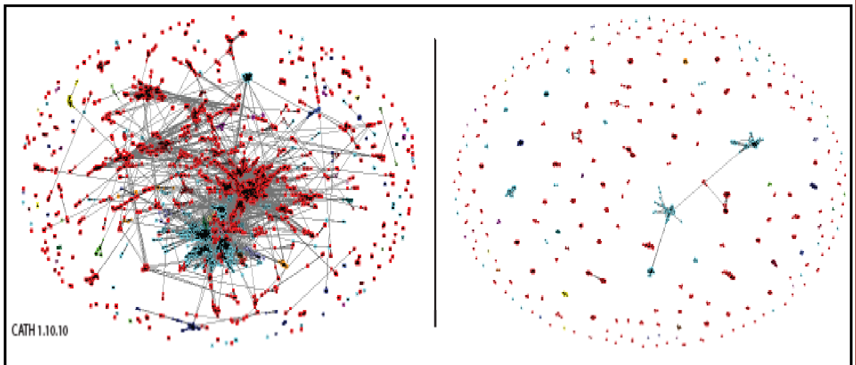
body responds by releasing endorphins and adrenalin. Adrenalin induces the fight-or-flight response and because one must stay stationary, this can be quite uncomfortable at first. *But eventually, the endorphins are absorbed by the body and prevent nerve cells from releasing more pain signals. During this period, different people feel different emotions, but most are calm and some even fall asleep. The hard part is over. You have the tattoo!

Not quite. Despite recent developments that make inks safer and more universally accessible, people can still have allergic reactions. Red and yellow dyes especially are known to often cause reactions. Red dyes can cause hypersensitivity of the skin because a lot of them contain metals and some may even contain mercury. While mercury in inks is obviously not FDA approved, some tattoo artists mix their own pigments, which can contain it. Another pigment that may cause allergic reactions is yellow dye. Most yellow dyes are made from cadmium sulfide, which is light-sensitive. Overexposure to sunlight can lead to severe sunburn. In general, the only light that affects tattoos is ultraviolet because it breaks down the chemical bonds in the dye, thereby dulling the pigment over time. A "no-no" immediately after getting a tattoo, though, is swimming, but not because of chlorine in a pool or salt in an ocean. It is because of the possible bacteria in bodies of water that can cause infection. A tattoo is just like an open wound and should be treated accordingly.

Now a look to the future: like Otzi, tattoos were once used for medicinal purposes, a sign of age, or rank. Tattoos are now personal and bear a certain meaning to the person who receives it. Though, history seems to be repeating itself. New scientific advances have led to using tattoos for medicinal purposes once again. With a rise in caffeine, stress, and checkups in our society, abnormal heart rhythms are increasingly detected. One of the main treatments for an abnormal heart rhythm is a pacemaker, which can now be wireless. Even though this technology is appealing, it also opens up risks for security breaches. In response, Microsoft Research proposed protecting the device by requiring a password. This password will be tattooed onto the patient in the invisible ink discussed earlier. Because of it, the signal cannot be hacked easily and can only be viewed by UV light device. As you can see, tattoos are not only growing in popularity, but have a real place in the sciences now and will continue to do so in the future.

Honors Research

Sarah Page
OC '15
Advisor:
Aaron Goldman



Cluster analysis results for natural and synthetic (left) protein domains and only natural (right) protein domains in the Arc Repressor Mutant, Subunit A fold (CATH 1.10.10). Analysis of natural and synthetic domains reveals synthetic connections greater than 50% similarity between groups of proteins previously thought to be unrelated (relatedness indicated by coloring).

Synthetic Biology Reveals a Continuity of Sequence Similarity Between Seemingly Unrelated Protein Structures

Some protein domains share a common structure but are dissimilar in amino acid sequence. It is not clear whether these proteins arose from an ancient common lineage or from two unrelated lineages that converged on a common structure. I used protein design software to create possible steps between these proteins. I found that some protein domains that traditionally have been classified as unrelated are connected by mutual sequence similarity to synthetic sequences. This result indicates a more fluid sequence space than previously thought.

Daniel Lowes
OC '15
Advisor: Tracie Paine

NMDA Receptor Antagonism as a Developmental Model of Schizophrenia

Schizophrenia is a psychiatric condition characterized by cognitive, positive, and negative symptoms. Epidemiological studies in humans and animal models of schizophrenia suggest that this disorder is related to altered brain development. One of these developmental animal models involves administering an antagonist of the glutamate-sensitive NMDA receptor to rats around the second post-natal week, which correspond to the third trimester of human development. In my project I administered the NMDA receptor antagonist MK-801 to rats during this time and looked for the presence of cognitive, positive, and negative symptoms during adolescence and adulthood through the use of tests of spatial memory, amphetamine sensitivity, and anhedonia and social withdrawal.

Gabe Moore
OC '15
Advisor: Maureen Peters

INX-16 mediated calcium wave is required for neuropeptide release in Caenorhabditis elegans

Neuropeptides are short amino acid chains that can act directly as neurotransmitters, or act indirectly by modulating neuronal activity. A neuropeptide, NLP-40, had been shown to have a role in regulating the defecation motor program. The defecation motor program (DMP) is a timed rhythmic behavior within the *Caenorhabditis elegans*, occurring every 45-55 seconds. The process consists of three muscle contractions: posterior body muscle contraction, anterior body muscle contraction, and enteric muscle contraction. Calcium stimulated NLP-40 release from the intestine appears to be essential for the last motor step in this motor program. Gap junction protein INX-16 allows for the flow of calcium through the intestine. Mutant strains containing a loss of function mutation in the *inx-16* gene demonstrate ectopic, missing, or slowed calcium waves, and also lack the last motor step. This project aims to understand in detail what aspect(s) of the signaling pathway between the intestine and the AVL/DVB neurons responsible for expulsion is/are defective in the *inx-16* mutant. *C. elegans*' relatively simple body plan makes them an excellent candidate for studying these molecular intestine/neuron interactions. Techniques used in this project include genetically engineered animals, fluorescence microscopy, and fluorescence resonance energy transfer (FRET) imaging.

Weelic Chong
OC '15
Advisor: Gunnar Kwakye

Gene-Environment Interaction in a Cell Model of Parkinson's Disease: Alpha-synuclein modulates cadmium transport dynamics and homeostasis

Parkinson's disease (PD) is a neurodegenerative disorder characterized by aggregation of alpha-synuclein (α-syn), whose function is unknown. Indeed, perturbations in a-syn function and metal homeostasis have been implicated in PD. The aim of our research is to uncover and examine gene-environment interactions between a-syn and acute metal toxicity. Utilizing an established dopaminergic cell model of PD that expresses human wild-type a-syn (N27-syn) or empty vector (N27-vec), I conducted a gene-metal screen to examine a-syn's neuromodulation of metal-induced toxicity. Here, I report that a-syn expression increases cadmium-induced neurotoxicity in a concentration-dependent manner. In addition, a-syn expression impairs cadmium transport and homeostasis through an oxidative-stress pathway. Our preliminary data elucidates how an environmental risk factor (cadmium) and a native protein implicated in PD (α-syn) may synergistically interact to cause neurotoxicity and aggravate PD progression.

The Oberlin College Convocation Series

Dr. Regina Benjamin

by Willa Kerkhoff

There are very few people in the world with a more impressive resume than Dr. Regina Benjamin. After growing up in Fairhope, Alabama and attending Xavier University followed by the Morehouse School of Medicine, Dr. Benjamin opened a rural health clinic in Bayou La Batre, Alabama, a small shrimping village on the Gulf Coast. She later served as the 18th Surgeon General of the United States, beginning in 2009 under the then-new Obama administration. As a politically powerful and personally engaging woman of color with twenty-two honorary degrees, a MacArthur genius award, and honors from organizations like the NAACP and the Catholic Church, she is impressive in the extreme.

Dr. Benjamin has been an advocate for both educational and financial accessibility of healthcare since her earliest years as a clinician. Working in Bayou La Batre put her in touch with people in truly desperate situations, situations that she could not always solve with a pen and a prescription pad. In some cases, human dignity and kindness were as important as accurate diagnoses. So when she moved into her new position in Washington D.C. and gained 300 million new patients, Dr. Benjamin chose to prioritize education and accessibility in her new healthcare initiatives.

The official policy put into place while Dr. Benjamin was Surgeon General is called the National Prevention Strategy. This strategy is based on preventative services, healthy and safe communities, an empowered and educated public, and the elimination of health disparities. The overall goal is to increase the number of Americans who are healthy at every stage of life. For Dr. Benjamin, this does not just mean a decreased risk of heart disease or a lower breast cancer rate. Dr. Benjamin also emphasizes the importance of combining mental

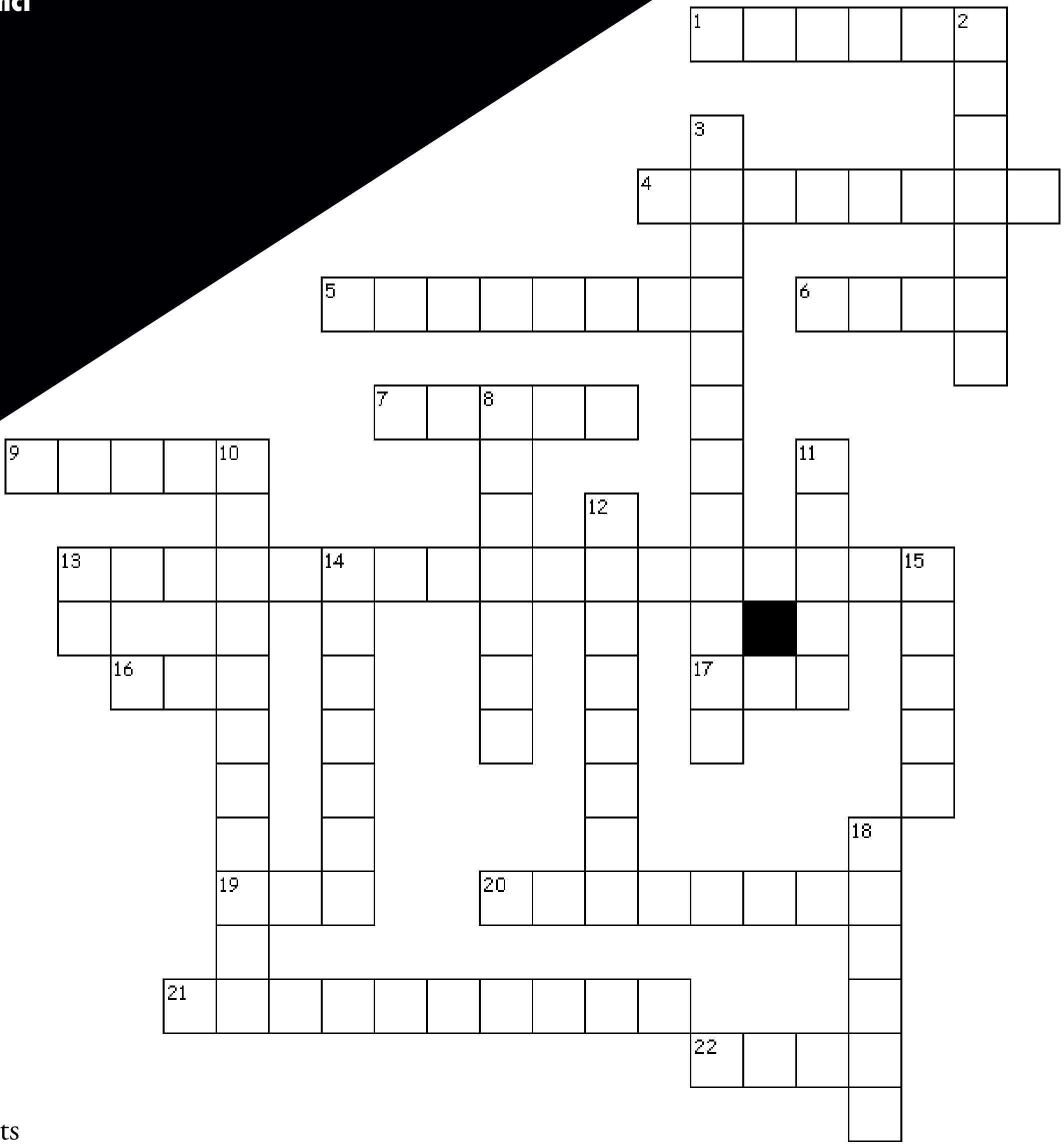
and physical health, saying, “It doesn’t matter your pace. Just do it.” If getting out of bed is an achievement, either because of clinical depression or because of a hip replacement, then getting out of bed is a step toward better health.

In person, Dr. Benjamin is both intimidating and personable. Her physical presence is commanding, and she speaks like someone used to delivering political addresses. And yet, after opening her talk by tweeting a photo of the crowd in Finney Chapel (her twitter is @ReginaBenjamin), she spoke earnestly and openly about the shortcomings of our current healthcare system.

Despite the ending of her tenure as Surgeon General, Dr. Benjamin is far from satisfied with healthcare in the United States. Questions from the audience during her convocation speech focused primarily on the challenges still extant in our current healthcare systems. In response to queries about everything from smoking amongst youth and obesity in children to mental health, Dr. Benjamin’s responses were consistent and clear: education and individual rights are paramount. Providing information is the responsibility of leaders and those in positions of power, but once the information is distributed, a personal choice must be made. Dr. Benjamin took a harder stance when asked about vaccinations; specifically, when asked what she would say to a parent who is choosing not to vaccinate their children, she quipped, “Keep them at home.” There are limits to what Dr. Benjamin will tolerate when it comes to the safety of others. However, she remains primarily committed to providing the tools for living a healthy life to as many Americans as possible. She has helped to shape the position of the Obama administration on every aspect of both physical and mental care. The scope of her impact cannot be underestimated. She will no doubt continue to change lives.

Crossword Corner

By Gabriel Hitchcock & Martin Mancinci



Across

1. Tattoo removal with ____
4. Field for biologically-based verdicts
5. Number of synapse authors
6. Bringer of war
7. Paradigm ____
9. Imaging the Earth in light spectrums *acr*.
13. The effect of GABA on the cellular membrane
16. Technique for amplifying genetic material *acr*.
17. Rox Anderson's removable invention
19. "Publish or ____"
20. Psychoactive constituent of *A. muscaria*
21. Replication and ____ (2w)
22. Oct4, Sox2, c-Myc, ____

Down

2. The point at which a nervous impulse passes from one neuron to another
3. Obsolete solitary confinement system
8. Number one in defense spending and number of ___
10. Mountains of the Guatemalan Highlands
11. Watson & ____
12. From common ____ arise common structure
13. What red dye and tuna have in common
14. Finnish god of thunder
15. What an elementary classroom, thunderstorms and bad data have in common
18. Neuropeptide-like motor protein

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For more about the bread lab, see www.thebreadlab.org

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/syn·apse/ *n.* the point at which a nervous impulse passes from one neuron to another

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